

What is Claimed:

1. A process for converting carbonaceous material into a product gas comprising:

drying a carbonaceous fluid to form a carbonaceous material having a solids content of at least 80%;

indirectly heating a fluidized bed, the fluidized bed containing particles suspended in a fluid medium;

injecting the dried carbonaceous material into the fluidized bed; and endothermically converting at least a portion of the carbonaceous material into a product gas stream.

2. A process as defined in claim 1, wherein the dried carbonaceous material has a solids content of at least about 90%.

3. A process as defined in claim 1, wherein the dried carbonaceous material has a solids content of at least about 95%.

4. A process as defined in claim 1, wherein the carbonaceous fluid comprises black liquor.

5. A process as defined in claim 1, wherein the fluidized bed is indirectly heated by at least one pulse combustion device, the pulse combustion device creating a pulsating combustion stream and an acoustic pressure wave that are transmitted through at least one resonance tube inserted into the fluidized bed.

6. A process as defined in claim 1, wherein the fluidized bed is maintained at a temperature of from about 1100 degrees F to about 1300 degrees F.

7. A process as defined in claim 1, wherein the fluidized bed is maintained at a temperature of less than about 1150 degrees F.

8. A process as defined in claim 1, wherein the fluidized bed is at a temperature and the dried carbonaceous material has an average particle size, a particle size distribution and a solids concentration such that the carbonaceous material forms a molten layer on the fluidized bed particles prior to being converted into a gas.

9. A process as defined in claim 1, wherein the carbonaceous material is injected into the fluidized bed in a carrier gas.

10. A process as defined in claim 9, wherein the carrier gas comprises steam.

11. A process as defined in claim 9, wherein the carrier gas comprises at least a portion of the product gas stream.

12. A process as defined in claim 1, wherein the carbonaceous material is injected into the fluidized bed so as to have an average particle size of from about 45
5 microns to about 120 microns.

13. A process as defined in claim 4, wherein the fluidized bed particles comprise sodium carbonate.

14. A process as defined in claim 1, wherein the product gas is filtered to remove entrained solids.

10 15. A process as defined in claim 1, wherein the product gas is fed through a scrubbing device for removing sulfur compounds contained within the gas.

16. A process as defined in claim 1, wherein the carbonaceous material is dried in a second fluidized bed.

15 17. A process as defined in claim 16, wherein the carbonaceous material is fed to an evaporator prior to entering the second fluidized bed.

18. A process as defined in claim 1, wherein the carbonaceous material is endothermically converted in the fluidized bed in a manner such that substantially no slag is formed.

20 19. A process for producing a product gas having heat or fuel value comprising:

feeding a carbonaceous material to a first fluidized bed, the first fluidized bed containing particles suspended in a fluid medium;

indirectly heating the first fluidized bed with a combustion device, the first fluidized bed being heated to a temperature of less than about 1200 degrees F, at least
25 a portion of the carbonaceous material being gasified to form a first product gas stream;

extracting bed solids containing carbon from the first fluidized bed and feeding the extracted solids to a second fluidized bed, the second fluidized bed being at a temperature higher than the temperature of the first fluidized bed, the second fluidized bed having a fluidizing medium comprising steam and an oxygen-containing gas,
30 wherein at least a portion of the carbon contained in the extracted bed solids is gasified to form a second product gas stream.

20. A process as defined in claim 19, wherein the first fluidized bed is maintained at a temperature of less than about 1150 degrees F.

21. A process as defined in claim 19, wherein the carbonaceous material comprises black liquor.

5 22. A process as defined in claim 19, wherein the first product gas stream is fed to a filtering device for filtering solids entrained in the product gas stream, the filtered solids being recirculated back to the first fluidized bed.

23. A process as defined in claim 19, wherein the fluidizing medium fed to the second fluidized bed contains oxygen in a stoichiometric amount of less than about 50%
10 based on the amount of carbon in the bed.

24. A process as defined in claim 19, wherein a portion of the carbon contained in the extracted bed solids is oxidized in the second fluidized bed, while another portion of the solids contained in the extracted bed solids is endothermically converted to a gas in the second fluidized bed.

15 25. A process as defined in claim 19, wherein the portion of the carbonaceous material gasified in the first fluidized bed is endothermically converted to a gas.

26. A process as defined in claim 19, wherein the fluidized bed particles contained in the first fluidized bed and the second fluidized bed comprise sodium carbonate.

20 27. A process as defined in claim 19, wherein the second fluidized bed is heated by oxidizing carbon in the bed.

28. A process as defined in claim 19, wherein the second product gas stream is filtered in order to remove entrained solids.

25 29. A process as defined in claim 19, wherein bed solids are periodically extracted from the second fluidized bed.

30. A process as defined in claim 29, wherein the recirculated bed solids are mixed with the carbonaceous material being injected into the first fluidized bed.

31. A process as defined in claim 19, wherein the first product gas stream is combined with the second product gas stream.

30 32. A process as defined in claim 19, wherein the combustion device that indirectly heats the first fluidized bed comprises a pulse combustion device.

33. A process for producing a product gas having heat or fuel value comprising:

feeding a carbonaceous material to a fluidized bed, the fluidized bed containing particles suspended in a fluid medium, the fluidized bed including a top portion and a bottom portion, the bottom portion being in communication with a solids collection reservoir;

indirectly heating the fluidized bed with a combustion device, the fluidized bed being heated to a temperature of less than about 1200 degrees F, a portion of the carbonaceous material fed to the fluidized bed being gasified to form a product gas stream; and

feeding a gaseous medium through the solids collection reservoir, the gaseous medium comprising an oxygen-containing gas, the gaseous medium gasifying carbon particles that have accumulated in the bottom portion of the fluidized bed.

34. A process as defined in claim 33, wherein the fluid medium in the fluidized bed comprises steam.

35. A process as defined in claim 33, wherein the fluidized bed is heated to a temperature of less than about 1150 degrees F.

36. A process as defined in claim 33, wherein the fluidized bed is heated to a temperature of less than about 1100 degrees F.

37. A process as defined in claim 33, wherein the product gas stream is fed to a filtering device for filtering solids entrained in the product gas stream, the filtered solids being recirculated back to the fluidized bed.

38. A process as defined in claim 33, wherein the gaseous medium fed through the solids collection reservoir contains oxygen in a stoichiometric amount less than about 50%.

39. A process as defined in claim 33, wherein a portion of the carbon particles contained in the solids collection reservoir are oxidized and wherein another portion of the carbon particles contained within the solids collection reservoir are endothermically converted to a gas.

40. A process as defined in claim 33, wherein the solids collection reservoir is maintained at a higher temperature than the fluidized bed.

41. A process as defined in claim 33, wherein the carbonaceous material comprises a black liquor.

42. A process as defined in claim 34, wherein at least a portion of the carbonaceous material fed to the fluidized bed is steam reformed to form the product
5 gas stream.

43. A process as defined in claim 41, wherein the particles suspended in the fluidized bed comprise sodium carbonate.

44. A process as defined in claim 33, wherein the combustion device that indirectly heats the fluidized bed comprises a pulse combustion device.

10 45. A process as defined in claim 33, wherein the particles suspended in the fluidized bed comprise sodium carbonate and the fluidizing medium comprises steam, the carbonaceous material being fed to the fluidized bed comprising black liquor, a majority of the black liquor being steam reformed in the fluidized bed, and wherein a portion of the carbon particles that have accumulated in the bottom portion of the
15 fluidized bed are oxidized, while another portion of the carbon particles are steam reformed.

46. A process for removing hydrogen sulfide from a product gas stream comprising:

20 contacting a gas stream containing hydrogen sulfide with an aqueous solution containing sodium carbonate;

reacting the hydrogen sulfide with the sodium carbonate to form a sodium sulfide and sodium bicarbonate, and wherein the sodium carbonate is contained in the aqueous solution at a concentration sufficient to cause the sodium bicarbonate to precipitate from the solution; and

25 filtering the resulting aqueous solution in order to remove the precipitated sodium bicarbonate.

47. A process as defined in claim 46, wherein the sodium carbonate is contained in the aqueous solution in an amount of at least 17% by weight.

30 48. A process as defined in claim 46, wherein the sodium carbonate is contained in the aqueous solution in an amount of at least 20% by weight.

49. A process as defined in claim 46, further comprising the steps of:

dissolving the precipitated and filtered sodium bicarbonate in water to form a solution; and

adding further amounts of sodium bicarbonate to the solution at an elevated temperature sufficient for the sodium bicarbonate to convert to sodium carbonate.

50. A process as defined in claim 49, wherein the sodium bicarbonate solution is heated to a temperature of from about 90 degrees F to about 130 degrees F.

51. A process as defined in claim 46, further comprising the step of steam reforming a carbonaceous material in a fluidized bed to form the gas stream containing hydrogen sulfide.

52. A process as defined in claim 51, wherein the carbonaceous material comprises a black liquor.

53. A process as defined in claim 51, wherein the fluidized bed contains bed particles suspended in a fluidizing medium, the bed particles comprising sodium carbonate, and wherein the process further comprises the step of extracting a portion of the bed particles and dissolving the bed particles in an aqueous solution in forming the aqueous solution contacted with the gas stream containing hydrogen sulfide.

54. A process as defined in claim 46, further comprising the step of contacting the resulting filtered aqueous solution with calcium hydroxide, the calcium hydroxide reacting with carbonates contained in the solution and forming a precipitated carbonate and sodium hydroxide.

55. A process as defined in claim 54, further comprising the step of filtering the solution to remove the precipitated carbonate and using the resulting filtered solution in formulating a pulping liquor for use in a pulping process.

56. A process as defined in claim 46, wherein the aqueous solution containing sodium carbonate that is contacted with the gas stream is preheated to a temperature of from about 90 degrees F to about 120 degrees F.

57. A process as defined in claim 49, wherein the resulting sodium carbonate solution is used in formulating the aqueous solution that is contacted with the gas stream containing hydrogen sulfide.

58. A process as defined in claim 46, wherein the aqueous solution that is contacted with the gas stream containing hydrogen sulfide is substantially saturated with sodium carbonate.

59. A process for removing hydrogen sulfide from a product gas stream
5 comprising:

contacting a gas stream containing hydrogen sulfide with a liquid containing an amine, the amine associating with the hydrogen sulfide in the gas stream and removing the hydrogen sulfide from the gas stream;

10 heating the hydrogen sulfide laden liquid containing the amine to release the hydrogen sulfide and form a gas stream;

oxidizing the hydrogen sulfide in the formed gas stream to form a flue gas stream containing sulfur dioxide; and

contacting the flue gas stream containing sulfur dioxide with an aqueous solution containing sodium carbonate causing sodium sulfite crystals to form.

15 60. A process as defined in claim 59, wherein the amine comprises a methyldiethanol amine.

61. A process as defined in claim 59, wherein the amine comprises a tertiary amine.

20 62. A process as defined in claim 59, wherein the amine comprises an alkanol amine.

63. A process as defined in claim 59, wherein the liquid containing the amine comprises an aqueous solution containing the amine in an amount from about 30% to about 60% by weight.

25 64. A process as defined in claim 59, wherein the hydrogen sulfide is oxidized in the presence of air.

65. A process as defined in claim 59, wherein the liquid containing the amine is heated to a temperature of from about 90 degrees F to about 150 degrees F when contacting the gas stream.

30 66. A process as defined in claim 59, wherein the hydrogen sulfide laden liquid containing the amine is heated to a temperature of from about 250 degrees F to about 350 degrees F.

67. A process as defined in claim 66, wherein the hydrogen sulfide laden liquid containing the amine is heated by contacting the liquid with steam.

68. A process as defined in claim 67, wherein the steam is under pressure.

69. A process as defined in claim 59, wherein the aqueous solution containing sodium carbonate is preheated to a temperature of from about 80 degrees F to about 140 degrees F when contacting the flue gas stream.

70. A process as defined in claim 69, wherein the aqueous solution contacting the flue gas stream is substantially saturated with sodium carbonate.

71. A process as defined in claim 69, wherein the aqueous solution contacting the flue gas stream contains sodium carbonate in an amount of at least 15% by weight.

72. A process as defined in claim 59, further comprising the step of steam reforming a carbonaceous material in a fluidized bed to form the gas stream containing hydrogen sulfide.

73. A process as defined in claim 72, wherein the carbonaceous material comprises a black liquor.

74. A process as defined in claim 72, wherein the fluidized bed contains bed particles suspended in a fluidizing medium, the bed particles comprising sodium carbonate, and wherein the process further comprises the step of extracting a portion of the bed particles and dissolving the bed particles in an aqueous solution in forming the aqueous solution contacted with the gas stream containing hydrogen sulfide.

75. A process for removing hydrogen sulfide from a product gas stream comprising:

contacting a first gas stream containing hydrogen sulfide with a liquid containing an amine, the amine associating with the hydrogen sulfide in the first gas stream and removing the hydrogen sulfide from the gas stream;

heating the hydrogen sulfide laden liquid containing the amine to release the hydrogen sulfide and form a second gas stream;

contacting the second gas stream with an aqueous solution containing sodium carbonate;

reacting the hydrogen sulfide in the second gas stream with the sodium carbonate to form a sodium sulfide and sodium bicarbonate, and wherein the sodium

carbonate is contained in the aqueous solution at a concentration sufficient to cause the sodium bicarbonate to precipitate from the aqueous solution; and

filtering the resulting aqueous solution in order to remove the precipitated sodium bicarbonate.

5 76. A process as defined in claim 75, wherein the amine comprises a methyldiethanol amine.

77. A process as defined in claim 75, wherein the amine comprises a tertiary amine.

10 78. A process as defined in claim 75, wherein the amine comprises an alkanol amine.

79. A process as defined in claim 75, wherein the liquid containing the amine comprises an aqueous solution containing the amine in an amount from about 30% to about 60% by weight.

15 80. A process as defined in claim 75, wherein the liquid containing the amine is heated to a temperature of from about 90 degrees F to about 150 degrees F when contacting the gas stream.

81. A process as defined in claim 75, wherein the hydrogen sulfide laden liquid containing the amine is heated to a temperature of from about 250 degrees F to about 350 degrees F.

20 82. A process as defined in claim 81, wherein the hydrogen sulfide laden liquid containing the amine is heated by contacting the liquid with steam.

83. A process as defined in claim 75, further comprising the step of steam reforming a carbonaceous material in a fluidized bed to form the gas stream containing hydrogen sulfide.

25 84. A process as defined in claim 83, wherein the carbonaceous material comprises a black liquor.

30 85. A process as defined in claim 83, wherein the fluidized bed contains bed particles suspended in a fluidizing medium, the bed particles comprising sodium carbonate, and wherein the process further comprises the step of extracting a portion of the bed particles and dissolving the bed particles in an aqueous solution in forming the aqueous solution contacted with the gas stream containing hydrogen sulfide.

86. A process as defined in claim 75, wherein the aqueous solution contains sodium carbonate in an amount of at least 15% by weight.

87. A process as defined in claim 75, wherein the aqueous solution contains sodium carbonate in an amount of at least 20% by weight.

5 88. A process as defined in claim 75, further comprising the steps of:
dissolving the precipitated and filtered sodium bicarbonate in water to form a solution; and

adding further amounts of sodium bicarbonate to the solution at an elevated temperature sufficient for the sodium bicarbonate to convert to sodium
10 carbonate.

89. A process as defined in claim 75, further comprising the step of contacting the resulting filtered aqueous solution with calcium hydroxide, the calcium hydroxide reacting with carbonates contained in the solution and forming a precipitated carbonate and sodium hydroxide.

15 90. A process as defined in claim 89, further comprising the step of filtering the solution to remove the precipitated carbonate and using the resulting filtered solution in formulating a pulping liquor for use in a pulping process.

91. A process as defined in claim 75, wherein the aqueous solution containing sodium carbonate that is contacted with the gas stream is preheated to a temperature of
20 from about 90 degrees F to about 120 degrees F.

92. A process as defined in claim 88, wherein the resulting sodium carbonate solution is used in formulating the aqueous solution that is contacted with the gas stream containing hydrogen sulfide.

93. A process as defined in claim 75, wherein the aqueous solution that is
25 contacted with the gas stream containing hydrogen sulfide is substantially saturated with sodium carbonate.